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SALINITY CONSTRAINTS TO DIFFERENT WATER USES IN COASTAL AREA OF BANGLADESH: A CASE STUDY

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Abstract

The present case study was an attempt to delineate the salinity related problems on multi-purpose uses of water and assess better water management options in a small scale water resources subproject in southwest coastal region of Bangladesh. The methodology of the study included application of a range of Participatory Rural Approach (PRA) tools and direct measurement of salinity in different sources of water. From the end of April till the beginning of June, salinity level both in the river and in the canal is considerably higher than drinking water standards as well as the standards for irrigation water. Salinity levels of groundwater at shallow depths (65 - 70 ft) are low, whereas salinity levels at deeper depths (840 - 1350 ft) are very high (3000 - 4000 μS/cm). Salinity in canal has been a constraint to irrigation water use and it has caused considerable yield reduction over the last 4 years, the reduction being from 5-5.5 to 2-2.5 ton/ha for *boro* and from 4.5-5 to 2.5 ton/ha for *aus*. A number of health related problems have been identified in the study area due to salinity, such as diarrhoea, fever, high blood pressure, gastric problem, skin problem, etc. One of the important management options is to repair the regulator gate and other possible management options could be application of gypsum, plantation of leguminous crops, selection of more salt-tolerant crops, harvesting rainwater, exploring suitable locations for tube-wells, which need to be tested and monitored on a regular basis.

Key words: Salinity, surface water, groundwater, agricultural water use, domestic water use.

Introduction

Water and soil salinity are normal hazards in many parts of the coastal area of Bangladesh, affecting different uses of water including irrigation, drinking, household, fisheries, and functioning of the ecosystem. Salinity in the river system of the southwest coastal region increases steadily from December through February, reaching maximum in the late March and early April (EGIS 2001). The impact of salinity on crop production as

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well as on aquatic environment is well documented (e.g. Karim *et al.* 1990, SRDI 2003, Uddin 2005). About 20% of the net cultivable land of Bangladesh coastal region is affected by different degrees of salinity (Karim *et al.* 1990). Lack of safe drinking water has been identified as the number one issue in the daily life of the coastal population. Commendable success has been achieved over the last few decades in providing safe drinking water, primarily through extensive exploitation of the available ground water resources. But in recent years, groundwater based water supply in coastal areas is suffering from a number of major problems, mainly arsenic contamination, lowering of the water table, salinity and non-availability of suitable aquifers (PDO-ICZMP 2004).

In the coastal region, a number of water resource projects have been implemented by Bangladesh Water Development Board (BWDB) and Local Government Engineering Department (LGED) to tackle the problems associated with different water uses originating from salinity, low dry season water availability, monsoon tidal flooding, etc. These projects typically included construction of embankments and regulators or sluice gates. The purpose of embankments is mainly to reduce flooding. Regulators/sluice gates are used for storage of tidal water and to facilitate drainage. These gates are also used for controlling saline water intrusion. In the dry season when salinity increases in the river, water is allowed to enter inside project areas during high tide by controlling sluice gates. Many a times, these structures do not work properly because of lack of maintenance, weak institutional arrangement and improper construction. This intrusion of saline water and irrigation with the saline water cause damages to crops and lands. However, the level of salinity problem is not the same in all parts of the coastal region. This paper presents the findings of an investigation of different issues associated with multiple use of water due to salinity in a small-scale water resources project as a case study. More specifically, the study attempted to characterize the salinity problems in surface water and groundwater in the project area, assess the impacts of water salinity on multi-purpose use of water (e.g. agriculture, fisheries, drinking and other household uses), and assess better water management options in terms of source and use.

Study area

The case study area was in Tripalli (Kakuibunia-Chinguri) flood control and drainage (FCD) sub-project, a small scale water resources sub-project of LGED, located in Patgati Union of Tungipara Upazila in Gopalganj (Figure 1). The sub-project was implemented in 2002 with a gross area of 425 ha and a benefitted area of 350 ha (LGED 2007). The major rivers in the study area, Madhumati and Ghagor, are tidal rivers. During the dry season, the low freshwater flow from upstream leads to high salinity levels, with salinity increasing steadily from December through February and reaching maximum in late March and early April. However, substantial freshwater flow from the upstream during the monsoon leads to minimum level of salinity in the rivers. The objectives of the project are: (i) reduce flooding from Ghagor river (locally also called Saildaha river) by constructing embankments with regulators added to facilitate drainage, (ii) improve drainage by re-excavating three channels, and (iii) improve navigation by constructing a small boat pass. The project also involved construction of a 4 km long embankment and 3 regulators, namely Kakuibunia regulator, Nabukhali regulator and Bushkhali regulator. Groundwater in Gopalganj district is available in a semi-confined aquifer with an average thickness of 6 - 10 m of an overlying clay layer (LGED 2007). However, in recent years arsenic contamination in groundwater has emerged as an acute problem; about 82% of tube-wells in Tungipara Upazila were found to be arsenic contaminated. The village Kakubunia was selected for detailed study. Contrary to the most of the other parts of Gopalganj, surface water (from Saildaha river) has been the only source of irrigation in the Tripalli sub-project. People use irrigation water from Kakuibunia canal and irrigation is mainly done by low lift pumps (LLPs). The length of the Kakuibunia canal is 440 m and depth is about 2 m. The Kakuibunia regulator is at a distance of about 45 m far from the Saildaha river.

Before implementing the project one crop was cultivated in a year but now two crops, namely *boro* and *aus*/*aman* are cultivated in a year. Almost all land (95%) is comprised of medium low land (inundation depth 0.9-1.8m) and low land (inundation depth >1.8m). The project appraisal report of LGED (1998) projected that due to the construction of the embankment in Tripalli subproject, the amount of low land (F_3) and medium low land (F_2) would be reduced from 121 to 115 ha, thus reducing fish yields by 60%. Later, some habitat expansion or improvement was achieved through channel re-excavation and water retention. In Kakuibunia village drinking and some household water needs (e.g. cooking) are met from groundwater using deep hand tube-wells (lowered at 840 to 1200 ft) due to arsenic problem at shallower depths. There are 7 such hand tube-wells in the study area.

Materials and Methods

A techno-social methodology was adopted in the study, involving primary and secondary data collection and analysis, and measurement of water salinity in different sources at different locations in the study area. Primary data (salinity data and salinity related issues) were collected through direct measurement of water salinity and through field research following Participatory Rural Approach (PRA) during three field visits made to the study area. The major sources of secondary information were Local Government Engineering Department (LGED), Department of Public Health Engineering (DPHE), and Upazila Agricultural office.

Salinity was measured in the study area at different times of river water, canal water, pond water and groundwater. Locations of the places from which the samples were collected are shown in Figure 1. Major locations included Saildaha river, Kakuibunia canal (inside and outside the gate), deep hand tube-wells and shallow hand-tube-wells. The first sets of measurements were made in last week of April in 2009 and the second sets of measurements were made in second week of June in 2009.

The PRA tools used in the study included Resource Mapping (to locate existing land and water resources in the study area), Focus Group Discussions (FGDs) with three different groups (farmers, fishermen and women), Key informants interviews (KIIs) (to collect information on overall aspects of the study from informed local key persons, e.g. LGED officials, Upazila Agricultural Officers, Upazila Fisheries Department Officials), semi-structured interviews (to get a semi-quantitative information on salinity) and transect walk (to triangulate the findings from other sources).

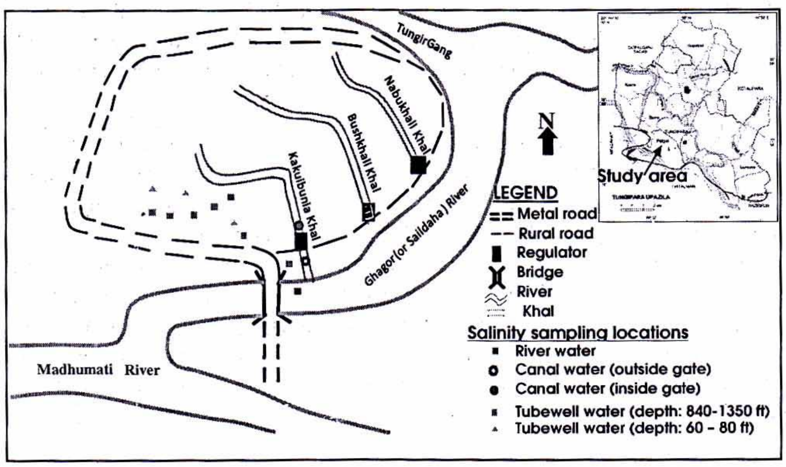

Figure 1. Study area showing salinity sampling locations.

Results and Discussion

Salinity problems in the study area

Saline water intrusion occurs in the months of March - May and salinity concentration in the river and canal becomes highest in the month of May. Local people also reported that the sluice gate is not functioning well because the size of the gate is shorter than required. As a result, some saline water enters into the canal even if it is closed.

Salinity in surface water system

Tables 1 and 2 present the measured salinity concentrations in Saildaha river and the Kakuibunia canal, respectively. As shown in Table 1, salinity in the river increased by about 3 times from April to June. Salinity in high tide was expectedly higher than that in low tide on a particular day.

Table 1. Level of salinity in the Saildaha river.

Date	Time	μS/cm	Standard value for irrigation water	Suitability
26/4/09	7:30 a.m.	1143		Suitable
09/06/09	9:14 "	3133	1200 μS/cm*	Not suitable
09/06/09	4:50 p.m.	3442		"

*MoEF, 1997.

Table 2. Level of salinity in the Kakuibunia canal.

Location	Date	Time	μS/cm	Standard value for irrigation water	Suitability
Inside gate	6/4/09	2:00 p.m.	898		Suitable
	26/4/09	7:35 a.m.	1439		Not suitable
	09/06/09	9:10 "	3155		"
	09/06/09	12:00 p.m.	3160		"
	09/06/09	4:00 "	3184	1200 μS/cm*	"
	09/06/09	5:00 "	3113		"
Outside gate	6/4/09	2:05 "	940		Suitable
	26/4/09	7:35 a.m.	1485		"
	09/06/09	9:06 "	3166		"
	09/06/09	12:05 p.m.	3210		"
	09/06/09	3:50 "	3208		"
	09/06/09	4:52 "	3138		"

*MoEF, 1997.

As shown in Table 2 it was observed that from the end of April till the beginning of June, salinity level is considerably higher than drinking water standards as well as the standards for irrigation water. There are diurnal variations in salinity both inside and outside the gate, as shown in Figure 2, with salinity being high during flood tide and low during ebb tide. The differences in salinity, however, are comparatively small. While it is clear that the saline water leaking underneath the faulty gate towards the inside of the project makes the salinities similar (in range) to that outside the gate, there is a dampening effect and a time lag, which is manifested in the lower salinity levels inside the gate and the peak of salinity level inside the gate occurring later.

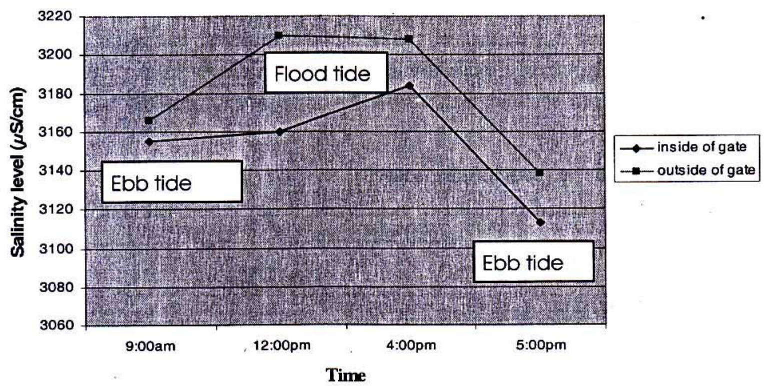

Figure 2. Changes of salinity level inside and outside the gate during high and low tide.

Salinity in groundwater system

The measured salinity levels in the tube-wells are presented in Table 3. In the Kakuibunia village, the local people use water for drinking and household purposes only from 7 deep set hand tube-wells (840 to 1200ft). Salinity levels at deeper depths (840 - 1350 ft) are very high (3 times or more than the tolerable limit 600-1000 µS/cm for drinking water standard) whereas salinity levels at shallow depths (tube-wells 6, 7 and 8) are low. However these shallow depth tube-wells are not used by the local people because of high arsenic contamination.

Table 3. Concentration of salinity in the water of hand tube-well.

Number of hand tube-wells	Depth (ft)	Time	µ S/cm	Standard value for drinking water	Suitability
		6/4/09	>3999*		Not suitable
1	900	26/4/09	>3999*		"
		09/06/09	>3999*		"
2	840	09/06/09	>3999*		"
3	840	09/06/09	3019		"
4	1250	09/06/09	3488	600-1000 µS/cm**	"
5	1300	09/06/09	3808		"
6	65	09/06/09	1225		-
7	70	09/06/09	1028		-
8	70	09/06/09	1003		-
9	880	31/12/09	>3999*		"
10	880	31/12/09	>3999*		"

* The upper measurement range of EC meter was 3999 µ S/cm, **MoEF, 1997.

Salinity constraints to different water use

Constraints to irrigation water

In the study area the villagers grow many crops and vegetables all year round. Farmers of this area are facing considerable problems relating to crop production due to use of saline water for irrigation. Table 4 gives an indication of the vulnerable crops to salinity. The irrigated *boro* and *aus* crops are the principal crops among them. The principal reason for this is attributed by the farmers to be soil salinity. In the opinion of the farmers, salts have accumulated in the soil for several years because of continuous irrigation with saline water and inadequate flushing in the wet season. In case of seedlings of rice, it turns into red color after 5 to 7 days of irrigation. Plants become weak, turn into reddish color and finally get burnt. If saline water is used for irrigation during ripening time of rice (*boro*), insects (locally called "Mow Poka") attack the paddy. This has resulted in reduction of yields to a great extent. In case of onion plants, growth is not satisfactory, as plants became shorter, weak, and whitish in color and the roots also got rotten. Chili becomes drier before harvesting time. Table 4 presents a clear indication of the great economic losses experienced by the farmers due to salinity.

Table 4. Reduction in yield due to salinity.

Crop	Yield		% reduction
	Past (Before 3 - 4years)	Present	
Boro	5 - 5.5 ton/ha	2 - 2.5 ton/ha	60
Aus/aman	4.5 - 5 "	2.5 "	50
Onion	9 - 12 "	3 - 4.5 "	65
Chili	2.5 - 2.7 "	0.6 - 0.9 "	75
Garlic	0.45 - 0.6 "	0.3 - 0.4 "	33
Jute	3.5 - 4 "	2 "	50

Constraints to domestic water use

Through interview with some people of the study area, it was revealed that people suffer from various diseases like diarrhoea, fever, high blood pressure, gastric etc. due to drinking saline water. Children mainly suffer from diarrhoea and fever. The women could strongly relate different health related problems to salinity. For example, pregnant women among the respondents (in the semi-structured interviews) who developed oedema (swollen legs) during pregnancy reported that their problem did not improve even when they stopped taking extra salt with their daily food on doctor's advice.

The villagers also reported during FGDs and interviews that their bodies become glutinous after bathing, which creates etching and ultimately leads to black spots on skins. Cloths do not become clean properly. When this river water is used for cooking, more time is required for cooking food and the cooked food becomes rotten very early. Some vegetables like puishak, potol, data shak etc. get rotten easily due to salinity.

Constraints to aquatic lives

In the study area all the traditional fishermen catch fish from the river. The availability of fresh water fish has decreased due to salinity. About five years ago, fishermen caught fresh water fish in the amount of 10 kg/day on average, which has now decreased to about 3 kg/day due to salinity. During FGD with the fishermen, it came out that while salt water fish species like chapila, zatka, baghda, prawn, hilsha, poa, etc. are found in the river, fishes like tengra, puti, khoilsha, koi, shing, shol, taki, bali, kachki, mrigel, aeir etc. are not presently found or found in trace amounts in the river, because of increasing salinity. Fishes found in the low lying areas are decreasing due to the intrusion of saline water. Besides fish, growth of most of the aquatic plants is being affected by salinity which has adverse impact on fish. Local people also reported that with increasing salinity in the river water hyacinth (locally known as kachuripana) dies drastically.

Conclusion

Salinity in Kakuibunia canal has been a constraint to irrigation water use. Salinity has been a problem mainly for irrigated *boro* and *aus* crops. It has been a problem also for rabi crops. Many of the fresh water fishes which used to be found before have diminished due to increasing salinity level in the Saildaha river. Almost all the people of the study area use deep hand tube-well water for drinking purpose but people seemed less concerned as they were unaware of the salinity concentrations as found by direct measurements (from 3000 to > 4000 μS/cm, which is 3 times or more higher than the drinking water standard). One of the important management options is repairing the Kakuibunia regulator. Other possible management options could be frequent irrigations, selection of more salt-tolerant crops, additional leaching, and heavy pre-plant irrigation. DPHE needs to play a bigger role in exploring suitable locations for tube-wells, which need to be tested and monitored on a regular basis. Rainwater harvesting can be an alternative source of water. It will, however, need building awareness among the people as they are not too familiar with the system.

References

EGIS. 2001. Environmental and Social Impact Assessment of Gorai River Restoration Project, Vol.1, Bangladesh Water Development Board.

Karim, Z., S. G. Hussain and M. Ahmed. 1990. Salinity Problems and Crop Intensification in the Coastal Regions of Bangladesh. BARC Soil Publication No. 33, Dhaka, pp. 63.

LGED. 1998. Kaikubunia-Chinguri Subproject SP-42 Gopalganj District, Tungipara Thana, Combined Summary Appraisal Report and Summary IEE Report, Small Scale Water Resources Development Sector Project, Local Government Engineering Department, Government of the People's Republic of Bangladesh.

LGED. 2007. District Water Resources Assessment Gopalganj, Second small scale water resources development sector project, Local Government Engineering.

MoEF. 1997. Ministry of Environment and Forest, Government of Bangladesh, Water Quality Standards for Drinking and Irrigation by Gazette Notification in 1997, Government of the Peoples Republic of Bangladesh.

PDO-ICZMP. 2004. Living in the Coast-Problems, Opportunities and Challenges, Program Development Office for Integrated Coastal Zone Management Plan, June 2004.

SRDI. 2003. Soil Salinity in Bangladesh, Soil Resources Development Institute (SRDI), MoA, Government of the Peoples Republic of Bangladesh, November 2003.

Uddin, M.N. 2005. Changes of Environmental Parameters due to Salinity Intrusion in the Southwest Region of Bangladesh, M.Sc. Thesis, Institute of Water and Flood Management, BUET, Dhaka.

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